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Forestry Research West

A report for land managers on recent developments in forestry research at the four western Experiment Stations of the Forest Service, U.S. Department of Agriculture.

Forestry Research West

In This Issue

Cover

This aspen stand is in an advanced stage of overstory decline—note the absence of new suckers. This is just one of the topics addressed in a new booklet on silviculture of aspen forests. Details begin on page 15.

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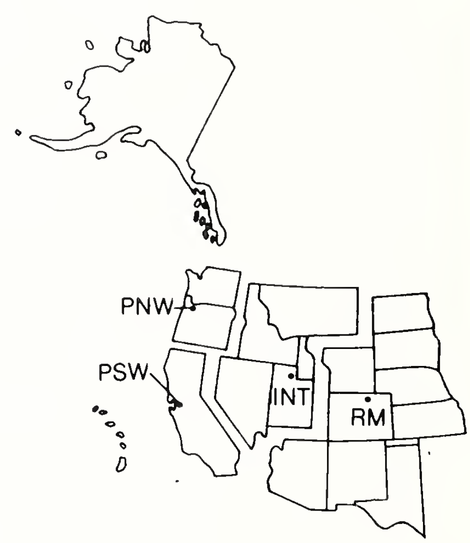


Silviculture research in forests of the Inland West

by Mike Prouty
Intermountain Station

Some called it individual tree cutting, or partial cutting. Others called it highgrading. No one really knew how old growth forests in the Inland West were responding to this harvest method. But until the mid 1950's the common cutting practice in Montana and other western States was to harvest "pumpkins"—the large, mature trees that brought the best dollar at the mill. Smaller trees, less desirable species, or trees with poor form were left in the woods, ostensibly to grow the next forest.

It was soon apparent to forest managers in the northern Rockies that this practice was changing the character of these cutover forests. Less valuable fir species were taking the place of the prized larch and ponderosa pine. That's when managers turned to the Forest Service's Northern Rocky Mountain Experiment Station (now the Intermountain Research Station) for help.

Thus began the Intermountain Station's Subalpine Silviculture research work unit, now located at the Forestry Sciences Laboratory in Bozeman, MT, and led by Project Leader and Research Silviculturist Wyman Schmidt. Schmidt leads a diverse group of scientists including Research Forest Biologist Clint Carlson, Research Silviculturists Ray Shearer and Dennis Cole, Foresters Ward McCaughey and Jack Schmidt, and Biological Technician Leon Theroux.

Silviculture research is helping managers understand the effects of fire, thus enhancing its usefulness as a tool in managing conifer forests of the West.

The original research effort, initiated to address harvesting, stand growth, and regeneration of partially cut forests, has survived various organizational changes, taken on added directions, and remained an important part of the Intermountain Station's research program.

Perhaps one reason for the longevity of this research unit is the integral nature of silviculture. Schmidt states, "Silviculture is the science and art of managing forests to meet resource needs. No matter the resource or management objective—be it esthetics, water, timber, wildlife, or recreation—silvicultural practices are the driving force, the means used to achieve the desired end."

Reversing the successional process

Back to the original problem—how to ensure healthy young stands of larch and ponderosa pine? INT scientists took a hard look at the forces of change in the partial cut forests of the Inland West. Their research helped steer timber management practices back to a path that would promote establishment and growth of larch and ponderosa pine forests.

Historically, fire played an important role in the West. Frequent small fires caused by lightning or Indians were common. Their effect was twofold: they killed the firs while the more fire-hardy pine and larch survived. Fire also created openings in the forest, allowing the full sunlight necessary for pine and larch to germinate and grow.

Fire control and partial cutting hindered this process. Partial cutting seldom created openings large enough to create full-sunlight growing conditions for larch and pine. And the competing fir species thrived in the moist, shady conditions caused by less frequent fires—a result of energetic, well intentioned fire control efforts. These two factors caused the species and the stand structure of these forests to change—from larch and pine to the more shade-loving firs, and from an even-aged to an uneven-aged forest.

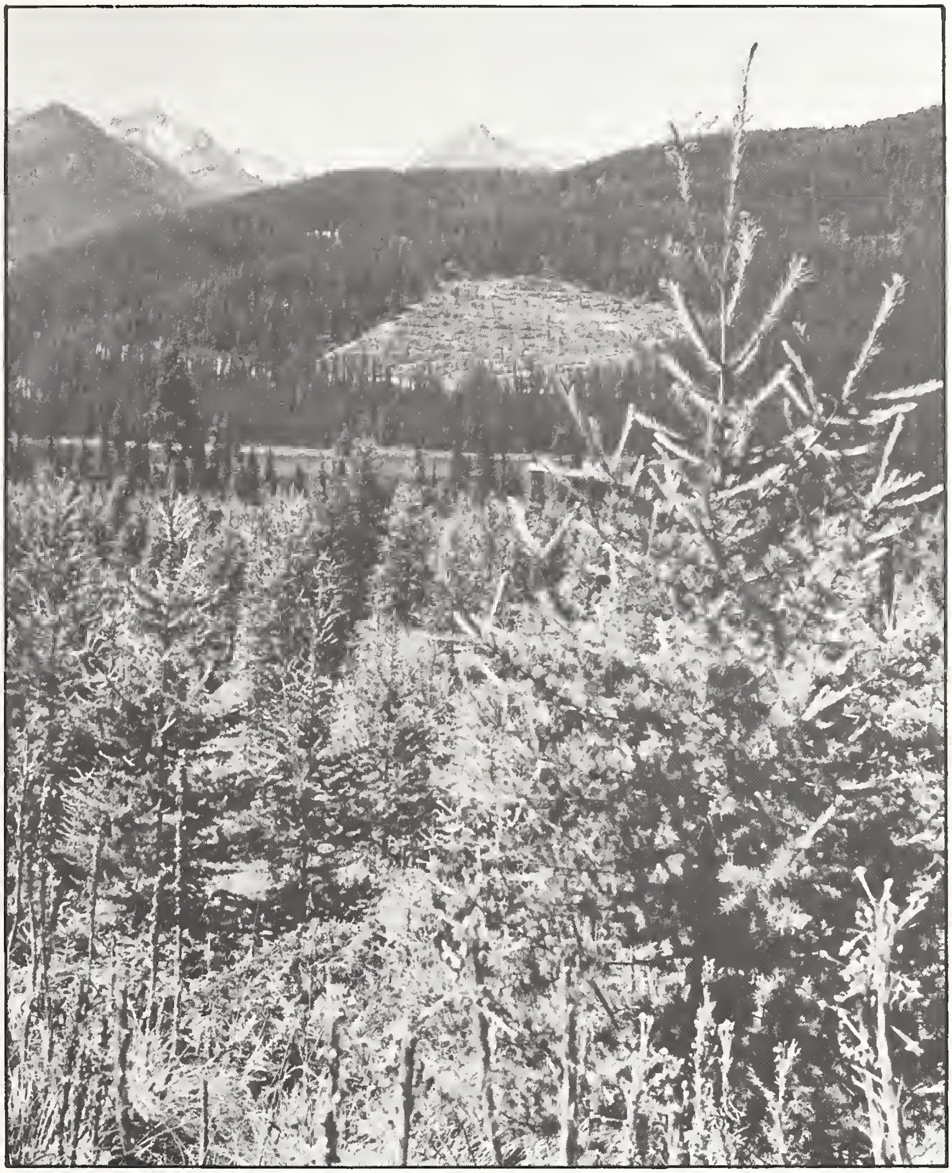
As a result of this research information, the practice of partial cutting was scrutinized by forest managers in the mountainous forests of the Inland West. Partial cutting was not completely abandoned, but its use was refined and applied to areas where it made silvicultural sense. Other harvesting prescriptions such as clearcutting, shelterwood, and seed tree cuts became more prevalent, creating small openings in the forest and returning them to an even-aged condition. Fire, once restricted outright, became a management tool. Managers began to use planned fire to remove slash and prepare seedbeds to improve natural regeneration of pine and larch.

What to do with young stands?

This early regeneration research led Schmidt and his associates into research related to improving the management of young stands. As Schmidt states, "We had young stands developing after 20 years of harvesting old growth forests, so we had to learn what to do with them, how to manage them."

To get a handle on management of young stands, research unit personnel began numerous studies designed to provide information on a variety of aspects of immature stands of trees. They established a series of long-term stand density studies in lodgepole pine and western larch forests. Other members of the work unit studied how different densities of trees affected water yield and understory vegetation. Still other scientists were investigating the interaction of different silvicultural practices and insect populations.

The payoff of this research effort in young stands is still being realized. Recently Schmidt and other members of his work unit played a lead role in a major symposium, "Future Forests of the Mountain West." Forest managers and scientists from across the country gathered at this symposium to compare information and discuss new information regarding immature stands.



A major emphasis of unit personnel is research directed toward managing young forests of the Inland West.

Forest residue research

When the silviculture research unit began in the late 50's, forestry was perceived by some to be a means to a single end—timber. But by the early 70's, this perception had changed. Forests were seen by the public as America's great playground, and the camping, hiking, picnicking, and wildlife as products of National Forests became significant.

As more and more people ventured into the forests, managers realized that how the forest looked was an important consideration in planning timber harvesting. The public simply wouldn't stand for activities that reduced the quality of their recreational experience. Managers were faced with several questions. What to do with the slash and residue left after timber harvest? Could it feasibly be removed? Would there be any negative effects associated with such an action?

Again, management questions resulted in research involvement. Realizing that public pressure would demand that slash from timber harvesting would have to be removed one way or another, INT initiated a series of forest residue studies aimed at establishing silviculturally sound methods for reducing slash.

Work unit researchers studied the removal of varying amounts of residue from clearcuts, shelterwoods, and group selection harvest areas. They studied the effect of this residue removal on natural and artificial regeneration, on understory vegetation and associated wildlife, and on water yield.

They found that some residues should be left on the site, that managers should not be overly zealous in removing every stick and limb from a harvest unit. And they developed silvicultural guidelines to help managers meet the needs of the public as well as the biology of a harvest area.

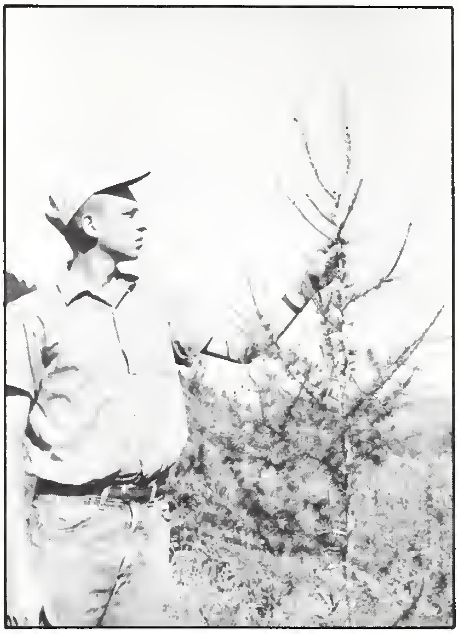
CANUSA

The research related to regeneration, young stand management, and forest residues represented a significant contribution to forest management. But the research that has attracted more public attention has been the unit's work involving the western spruce budworm.

This insect is a major defoliator of forests across the United States. In the early 1950's, the standard control procedure was to load up a fleet of old World War II bombers with the insecticide DDT and spray millions of acres of forest. DDT was effective at killing the budworm (and other organisms). But invariably, the budworm would be back in a few years, and each time they would seem to be a bit more resistant to DDT, requiring larger and larger doses.

"We were strong-arming an ecosystem," says Schmidt. "We'd kill a lot of bugs, but we'd also kill predators and parasites. The surviving bugs would come back stronger and faster than ever, as they were filling an ecological void caused by the insecticide."

Then came "Silent Spring," by Rachel Carson. The environmental movement and concern over insecticides was born.



Budworm feeding has caused the fork on this young western larch, reducing both its good form and rapid height growth.

By the mid-70's managers and scientists in Canada and the United States recognized that something different had to be done to better live with this forest pest. A major cooperative research program—CANUSA—was initiated to find alternative ways to reduce losses from the budworm.

For much of the next decade, personnel in INT's subalpine silviculture research unit assumed a major role in the western portion of this international research program. The program would result in over 50 publications, three Department of Agriculture and one Canadian texts, and four major symposia.

Schmidt and his associates were given the task of examining how silvicultural practices in western forests affected the natural ecology of the budworm. "We asked ourselves why this insect, around for hundreds of years, had apparently never had such a population explosion before the 1950's," says Schmidt. "Our studies soon revealed that the same partial cutting and fire control policies that were changing the species composition and stand structure of our forests were also creating ideal habitat for western spruce budworm. The budworm thrives in dense, multistoried forests composed of trees they most prefer to feed upon—grand fir, Douglas-fir, and subalpine fir. No wonder the population of spruce budworm soared. We were our own worst enemies. We learned that recent clearcuts, seed tree cuts, and shelterwoods were not the problem. Instead, the best silvicultural practices for the forest were also the best way to reduce outbreaks of western spruce budworm," says Wyman.

Cooperative research

While the work unit's involvement in CANUSA attracted attention, Schmidt is quick to point out the other important work of the unit. "Research Forester Jim Lotan's early work in the unit contributed greatly to the knowledge of the silvics of lodgepole pine," says Schmidt. "And we are conducting cooperative research regarding silvicultural alternatives in control of the mountain pine beetle."

In fact, cooperative research is a strong characteristic of the unit's research. Unit personnel are involved in joint research involving soil, water, insects and disease, understory vegetation, fire, and animal damage relationships to various silvicultural practices.

"One reason we're involved in so many different areas relates again to the nature of silviculture," says Wyman. "By its very definition, silviculture research is very integrative. There are very few scientists in this project who specialize in one area. We look at the broad implications of a problem as it relates to multiple resources. We cooperate with scientists who specialize in a specific problem. I think our contribution is helping translate the resolution of the problem to on-the-ground silvicultural practices. Our research perspective complements fire, insect, and timber harvesting research, to name a few. And I think this broad perspective—the fact that the results of our work usually have direct implications to management—is one reason why we've always had great support from user groups."

Research unit personnel conduct cooperative studies with scientists from other work units within INT and other Forest Service research stations. They also conduct cooperative studies with scientists at the Universities of Montana, and Minnesota; Montana, Washington, and Utah State Universities; and Brigham Young University.

With work unit personnel going in so many directions at once, how does Schmidt keep a perspective on the unit's research mission? "I've been project leader for 13 years," says Schmidt. "Each year we all gather to discuss the general thrust of our work. During the rest of the year there's constant communication among the group. We jointly develop direction of our research, assign it to individuals, and then give them a lot of independence. I believe independence is essential to creativity, and that's what research is all about. And over the years I've tried to make sure the people in this unit are the type that can handle that independence in a responsible, productive manner."

New areas of work

To what will the energies of unit personnel be devoted next? Schmidt points to cone and seed research, prescribed fire and other cultural practices in young forests to reduce insect and disease problems, and research related to high-elevation species such as whitebark pine, as areas that will receive increasing attention.

"Cone and seed production of western larch has always been a pretty iffy proposition," says Schmidt. "We're involved in a cooperative study with the Intermountain and Northern Regions to find out why larch cone crops have been so sporadic in recent years—especially at the margin of this tree's range—and what we might be able to do about improving the situation."

"Our research in this area is just begining to identify some of the factors behind these recent poor cone crops," says Schmidt. "We're learning that a combination of physical and biological factors—including both weather and insects—play a prominent role in the success or failure of larch cone crops. But we still have a long way to go in understanding this phenomenon."

Insect problems have plagued forest managers in the West. Until recently, research and management concentrated its efforts on forest pests associated with mature and overmature forests. With the ultimate objective of preventing or limiting most insect problems, Schmidt and his associates are focusing their research on host-pest interactions in immature forests, believing silvicultural practices can create conditions less favorable for insects and more favorable for the trees. They are currently testing thinning and prescribing underburning treatments in immature Douglas-fir–ponderosa pine stands to determine the effectiveness of these measures in reducing western spruce budworm populations. They are also studying the effect of thinning immature lodgepole pine forests in warding off mountain pine beetle attacks.

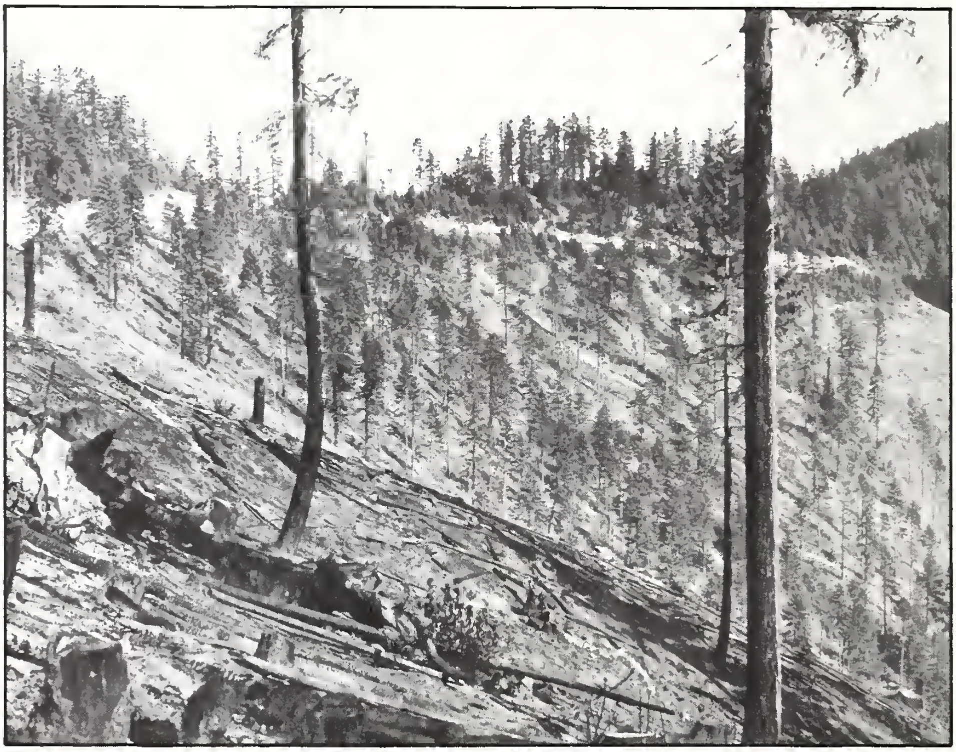
Schmidt points out that whitebark pine seed has been found to be an important staple in the diet of grizzly bear. But scientists and managers are concerned by the apparent decline in the number of mature, cone-bearing pine in some areas and lack of regeneration in others. Thus, personnel in the silviculture unit are studying the regeneration processes of whitebark pine.

Schmidt also points to the continuance of long-term studies as another important area of work for his work unit. "We have some studies that were established 40 years ago that are still providing new and important information," says Schmidt. Recently, research unit personnel played a lead role in a field workshop that described and reviewed new information regarding fire/regeneration relationships from study sites established in the Lolo and Flathead National Forests 20 years ago.

Clearly, the effort of personnel in INT's subalpine silviculture work unit is helping maximize the wise use and protection of the multiple resources contained in forests of the Inland West.

Getting trees to grow in southwest Oregon

by Dorothy Bergstrom
Pacific Northwest Station



Burning was used in preparing the site for planting in the shelterwood cut in the foreground.

Prompt delivery of research information to people who can put it to use has been the key to improving reforestation success in southwest Oregon—a part of the country where both planted and natural seedlings often have a hard time surviving because of the hot, dry summers and rocky, droughty soils. Successful reforestation appears to require a more precise match of silvicultural practices with the environmental conditions of planting sites than is required in other parts of the Douglas-fir region.

After 9 years of intensive basic and applied studies, scientists have concluded that seedlings can become established and grow well on these harsh sites when reforestation procedures combine high quality planting stock with adequate site preparation and weed control, good quality planting, and careful synchronizing of postplanting care with the local environment. The scientists have also refined procedures for steps in the reforestation process and increased the ecological knowledge base so that better on-the-ground management decisions are possible.

These results and conclusions are based on work that has been coordinated by a research, development, and application program called Forestry Intensified Research, or FIR, that was established in 1978 to accelerate research on reforestation problems in the area of Oregon that lies south and west of Roseburg.

The lack of reforestation success was acute in Jackson, Josephine, Douglas, and Curry Counties. Methods that worked in the moister parts of the Pacific Northwest, where most research had been concentrated previously, were not working in southwest Oregon. Many areas had been planted several times. Failure was more conspicuous at higher elevations and on south-facing slopes. The problem was present on both public and private land and did not vary much among the local commercial species, which included Douglas-fir, ponderosa pine, sugar pine, mountain hemlock, white fir, and Shasta red fir.

A program was begun

Although Forest Service and university scientists had long been concerned about the repeated failure of planted seedlings to grow, or even survive, after logging, no concerted action to tackle the problem was taken until the Medford District of the Bureau of Land Management decided to withdraw about 200,000 acres from the base of harvestable timber. The decision was based on evidence that certain difficult sites could not be reliably regenerated.

This threat to the economy of a region that had been producing about 5 percent of the Nation's lumber and about 20 percent of the veneer and plywood was enough to spur the coordinated effort that resulted in the FIR program.

Like most research, development, and applications programs, the FIR program was set up to accelerate and expand, over a 10-year period, research that was already underway and would continue long after the program's conclusion. The program was initiated with a cooperative agreement between the Pacific Northwest Station and Oregon State University to increase research efforts in southwest Oregon according to a plan drafted by 18 agencies, organizations, and timber firms.

Many agencies and organizations joined as cooperators. Lending financial and moral support were the Bureau of Land Management (BLM); the Oregon Department of Forestry; the governments of Douglas, Curry, Josephine, and Jackson Counties; three National Forests; the local forest products industry; and local forestry associations.

Most of the scientists have been stationed in Corvallis and Medford. Numerous field installations have been established throughout southwest Oregon. Many of the research plots are located on the BLM sites considered so difficult that they were withdrawn from timber production.

Speeding the practical application of new findings and spreading the word to the people who manage timberland have been the job of a group of research foresters working in Medford who make up the part of the program called "Adaptive FIR."

Improving basic knowledge about plant ecology, genetics, and physiology and describing environmental conditions have been the job of scientists in Corvallis who work at the Pacific Northwest Station's Forestry Sciences Laboratory and at Oregon State University. Their part of the program is called "Fundamental FIR."

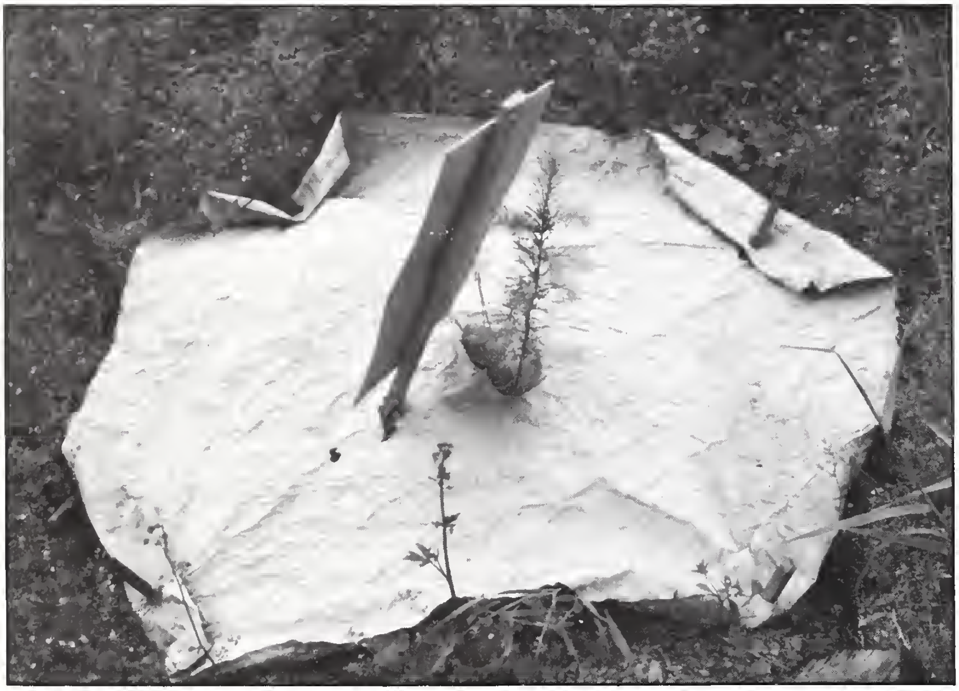
The first funding for the new program came in 1979, when Congress directed BLM to transfer $1.2 million to the Pacific Northwest Station and Oregon State University. Subsequent funding of about $2.5 million a year has come from appropriations to the Forest Service and BLM, and from cooperators.

According to Jack Walstad, who, since 1982, has been leader of the FIR program, "The key ingredient has been the Adaptive FIR station at Medford, which has fostered local participation and helped put the basic findings of Fundamental FIR into practice."

Pete Owston, leader of the reforestation research unit at the Pacific Northwest Station's laboratory in Corvallis, agrees. "The knowledgeable and energetic research foresters on the ground in Medford have gained broad local support. They have built rapport with cooperators and sensitized people to doing their jobs better," he says.

Why regeneration has improved

Research done as part of the program has touched nearly all aspects of tree genetics and physiology, silvicultural methods, and ecological relations that apply in southwest Oregon. The emphasis has been on finding out the specifics of reforestation problems, finding out why some standard procedures do not work in southwest Oregon, and what can be done to improve them.



A seedling in a progeny test is protected by a shade card and paper mulch.

The rate of reforestation success has increased as findings of basic and applied research have been translated into better practices in four general activities of reforestation: producing planting stock, site preparation, planting procedures, and synchronizing silvicultural activities with the local environment. Contributions to new knowledge in each of the general areas have come from work in a wide range of subject areas, which include soil microbiology, climate, harvesting, genetics, seed production, nursery management, animal damage, thinning, fertilization, mensuration, and economics.

The following are selected examples of recent research findings.

Genetics

Geneticist Bob Campbell has found that, in parts of southwest Oregon, Douglas-fir is growing near its physiological limits, as indicated by the presence of all-aged stands. Because Douglas-fir normally grows in even-aged stands in areas where it is well adapted, the all-aged condition indicates it is near its distributional limits and has difficulty regenerating itself. In these areas, special planting and tree-breeding procedures are needed to ensure successful regeneration.

Research has also found wide genetic diversity in the natural progeny under shelterwood stands, indicating that there is no threat to the natural genetic diversity when only a few trees are left to provide seed for natural regeneration.

Planting stock

High quality planting stock means healthy seedlings genetically adapted to conditions of the planting site. Recent genetics studies have defined breeding zones much more accurately than the zones that were established in 1966 and used until recently. The new zones reflect what is now known about how trees are genetically adapted to grow under complex environmental conditions that vary with latitude, elevation, and distance from the ocean and the importance of using seed collected from sites similar to those where seedlings will be planted. Seed zones vary by tree species.

Another way to assure better seedling quality is to provide suitable mycorrhizal fungi, which earlier research showed increased the capability of plant roots to absorb nutrients and moisture. Fungal species suitable for various tree species have been identified and cultured, and techniques for inoculating the soil of nurseries and greenhouses have been developed.

Still another method of ensuring that only good quality seedlings get planted is to use tests developed to detect frost damage and determine seedling vigor.

Synchronizing activities with environmental characteristics

The primary environmental factors that affect seedling survival and growth adversely are inadequate moisture and too much heat. On some high-elevation, level sites, summer frosts also damage seedlings. Site classification that is based on environmental differences that are

silviculturally important has helped to predict regeneration success. Classification has been based on measurements of such elements as rainfall, soil moisture and water storage capacity, air temperature, evaporation, solar radiation, wind, and humidity, and on the ranges and seasonal variations in these factors.

Another guide to environmental conditions is the presence of plant indicator species. For example, mountain hemlock indicates a particularly cold site. On such areas, scientists recommend saving the natural advance regeneration because the areas may be difficult to plant.

Site preparation and planting

Although forest managers cannot control the basic environment, they can use findings from applied research to modify the effect of local conditions and to make sure that seedlings are given the best start possible with proper planting.

Because competition with other vegetation for moisture is the number one problem, various methods have been used to remove brush before planting and to control competing shrubs and weeds. The primary competing species are various ceanothus and manzanita species, canyon live oak, Pacific madrone, and tanoak. Since 1984, when the use of herbicides on Federal land was suspended, various other methods of weed control, such as scarification by machine or hand-slashing have been evaluated, based on what has been learned about the development of shrub sprouts. Various mulches have also been used to conserve moisture.

For comparing reforestation systems, various combinations of site preparation and planting stocks were used to reforest side-by-side clear-cuts and shelterwood cuts.

Crews check survival and condition of seedlings during the first growing season on a clearcut in southwestern Oregon.

Protection from direct sun for part of the day reduces heat stress on seedlings. One method for doing this is to use shelterwood logging, which leaves scattered trees to provide shade. Measurements made in clearcuts and under shelterwoods indicate that temperatures are about 5°C higher in clearcuts. Another method is to place shade cards (rectangles of cardboard or plastic) on the south side of newly planted seedlings.

Another help for young seedlings is protection from ravel, or the downhill movement of rocks, soil, and vegetative detritus. One method is to deflect material around seedlings by various devices. These include placing shingles or a stake above each seedling.

In one large collaborative effort, Fundamental and Adaptive FIR scientists are comparing reforestation systems—not just individual practices. They divided side-by-side clearcuts and shelterwoods into burned and unburned halves. Then each of the four combinations was planted with four different types of planting stock. Half of each stock-type is protected from animal damage with plastic-mesh tubes or from radiation with shade cards. The results so far indicate no reason to deviate from the practices of harvesting by clearcutting, followed by burning to prepare planting sites—provided these and the subsequent reforestation practices are conducted properly.

Tours are one of the prompt, direct means of communicating with users of research information that help improve the rate of reforestation success.

Conclusion

The FIR team is taking results beyond the scientific-report stage and applying them to local conditions, and including forest managers in the process. Managers are consulted about problems and informed promptly about research developments through workshops, consultations, and field trips to research sites. "Having qualified people on the scene who can respond quickly with assistance and who encourage users to adopt new methods is what makes the FIR program successful and gives all of us a feeling of accomplishment," says Walstad. "We believe it is establishing a positive attitude toward research that will encourage future application of new information."

Additional information is available from Jack Walstad, 3200 Jefferson Way, Corvallis, OR 97331. To get on the mailing list to receive copies of the quarterly newsletter, "FIR Report," write to Adaptive FIR, 1301 Maple Grove Drive, Medford, OR 97501.

Preharvest burning to control postharvest vegetation

by Richard B. Pearce, for Pacific Southwest Station

Preharvest prescribed burning could become a practical alternative for controlling shrubs and other competing vegetation in regenerating forests. Results of a preliminary study carried out by C. Phillip Weatherspoon, research forester with the Pacific Southwest Station in Redding, California, suggest that the use of preharvest burning may significantly reduce reserves of dormant shrub seeds in the forest floor and soil. Such prescribed fires apparently kill many seeds outright and stimulate others to germinate; thus, the resulting seedlings can be eliminated by natural mortality in the closed stand, or by logging and postharvest site preparation activities.

Reducing the density of shrub seedlings in a regenerating forest gives young conifer seedlings a better chance to survive and grow. But many observers object to current manual and herbicidal methods of releasing plantations from competing vegetation. They feel such methods are too costly, dangerous, environmentally unsound, or just plain ineffective. That's why a simple alternative like a prescribed burn, applied before harvest, has the potential to become a valuable tool for forest managers and silviculturists.

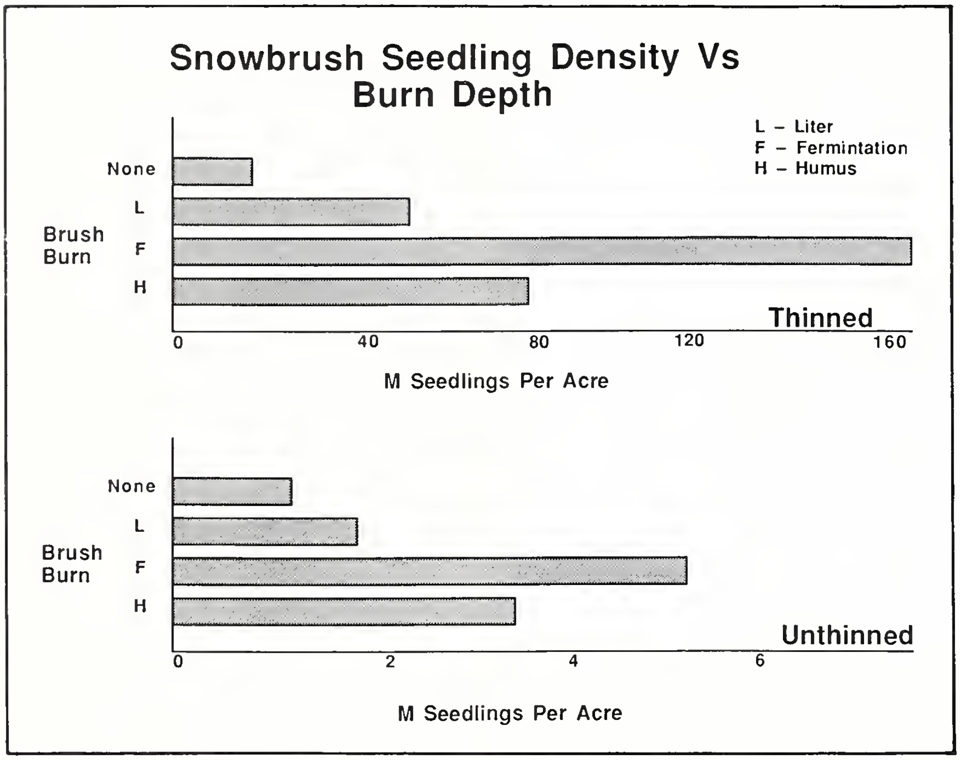
"The early data of our study support the possibility that preharvest burning could reduce the density or vigor of postharvest shrubs to the point that the need for later release treatments would be lessened or even eliminated," said Weatherspoon. "And although this preliminary study addressed only the question of shrub seeds and seedlings, other evidence suggests that the technique may also help to solve the additional problem of sprouting shrubs, a subject to be included in our future work. Preharvest burning," he added, "might be viewed as a component of various regeneration management schemes in which an effective preharvest treatment (like burning) would increase the options or reduce the costs of subsequent vegetation control activities.

"A side benefit with preharvest burning would be the significant reduction in fire hazard in many areas," he added.

Preharvest prescribed burning, being conducted here in a white fir stand, shows promise as a potential technique for reducing subsequent competing vegetation in conifer plantations.

The study

Weatherspoon conducted his experiments in a stand of nearly pure 60- to 70-year-old California white fir sawtimber (*Abies concolor* var. *lowiana* [Gord.] Lemm.) located in the Lassen National Forest at an elevation of 6,200 feet. When the study began, the canopy cover was almost complete. Scattered remains of shrub skeletons indicated that a brushfield had previously occupied the site.



Density of snowbrush seedlings depended on the layer of the forest floor into which the fire burned. Subjective observations suggested that in areas of "deep" (as opposed to "average") H-layer burns, seedling density approached zero.

The stand of immature sawtimber, along with commercial thinning, were employed to accommodate other study objectives. Weatherspoon noted, however, that the key findings regarding preharvest burning should be equally applicable to a regeneration situation—one in which the old stand is replaced by a new stand of conifer seedlings.

Three treatment variables were considered:

- **basal area** of timber remaining after commercial thinning.
- the **number** of burns, and
- the **season** of burn.

In all, 26 one-acre plots were studied, with measurements being taken in centrally located half-acre zones.

Plots which were burned twice were first burned in the spring of 1982. Thinning was conducted in the fall of 1982. Subsequent burns—either the second burn for the twice-burned plots, or the only burn for the once-burned plots—were conducted in the spring or fall of 1983. Unlogged plots could be burned only once—in 1983—because no timber harvesting slash was available to carry a second fire.

Shrub seeds were induced to germinate either by the heat of prescribed burning or by stand opening and mechanical scarification caused by timber thinning activities. Seedling densities for snowbrush (*Ceanothus velutinus*) and greenleaf manzanita (*Arctostaphylos patula*) were measured in the early fall of 1983 and again in the late summer of 1984.

For snowbrush, Weatherspoon discovered that the greatest difference in seedling density was between burned and unburned plots. For example, on unburned plots that had been thinned from a basal area of approximately 300 to 350 ft^2/acre to just 80 ft^2/acre, seedling density was only 1,700 an acre. In contrast, plots that were first burned then thinned produced 29,000 seedlings an acre. An even greater effect was observed on logged plots subjected to postharvest burning, in which more than 100,000 snowbrush seedlings could be counted per acre. Apparently, on this particular site, seed scarification caused by thinning alone was insufficient to induce an appreciable number of snowbrush seeds to germinate. Only when logging was preceded by preharvest burns and/or followed by postharvest burns did brush seedlings grow to high density.

Consumptive burn the key

As for the finding that snowbrush seedling density was less after preharvest burns than after postharvest burns, Weatherspoon surmises that the less consumptive nature of the former accounts for the difference.

"Under the moderate spring conditions of the preharvest burns, which included moist lower duff and soil, fewer seeds probably received the heat scarification needed for germination," Weatherspoon noted. This may also help to explain the observation that density of snowbrush seedlings on twice-burned plots, while statistically lower than that on once-burned plots (postharvest burn only), probably was not meaningfully lower from a biological or managerial standpoint. However, it's his working hypothesis that if a preharvest burn were carried out under drier conditions, either in the spring or fall,

more shrub seeds would be stimulated to germinate or be killed outright. A preharvest burn might then be quite effective in reducing the density of shrubs, he said.

Weatherspoon also found similar patterns of seedling density for manzanita after the various treatments. One difference, however, was that while the density of manzanita and snowbrush on unburned plots was about equal, manzanita on burned plots was less by a factor of 4 to 16. Weatherspoon thinks the most likely explanation is that mechanical scarification and opening of the stand were relatively more effective in stimulating seed germination in manzanita than in snowbrush.

The season of postharvest burning caused a difference in seedling density—higher for spring than for fall burns—but one that Weatherspoon considers biologically unimportant. The effect of season of preharvest burning, not directly investigated in this study, will be considered in his future research.

One of the more notable findings in the study was that seedling densities for both shrub species were dramatically lower in burned, uncut plots than in plots thinned by logging and then burned. For example, only 3,100 snowbrush seedlings per acre were counted in uncut plots burned in the spring of 1983 compared to 121,000 seedlings per acre for plots thinned to a basal area of 80 ft^2/acre and then burned.

In order for preharvest burning to become a useful forest management tool, it will have to prove workable in closed and relatively dense stands—frequently the condition of stands destined for regeneration. "So it's important to understand why so few seedlings were observed in the uncut burned plots," explained Weatherspoon.

"It seems likely," he said, "that seeds were poorly scarified and prepared for germination, just as in logged plots that were burned, but that the closed stand conditions somehow inhibited germination or caused very early mortality of seedlings."

Seed viability and burn depth

If most of the scarified seeds did not germinate, one must ask whether they would remain viable and therefore a potential threat when the regeneration cutting is carried out. Or, since they were now imbibed with water, would they instead experience high mortality from disease, insects, other seed-eating animals, and temperature extremes?

"Obviously, it is important to know which of these possibilities best describes what happens after burning in a closed stand," Weatherspoon acknowledged. To find out, he is currently sampling the vertical distribution of viable shrub seeds in burned and unburned, cut and uncut plots. To guide his work, he is using a model developed from observations of seedling densities and burn depth recorded in the preliminary study.

"Perhaps the most significant finding that came out of the study was the apparent dependence of seedling densities on local depth of burn," said Weatherspoon. He went on to explain that a burn depth producing temperatures appropriate for scarification in the zone of highest seed density would be expected to result in many seedlings of that species the following year. If, on the other hand, the burn was more consumptive—i.e., burned deeper into the forest floor—more seeds would be destroyed by lethal temperatures and fewer seedlings would be produced. The net result would be fewer remaining viable seeds.

In his study, Weatherspoon found that, for snowbrush, maximum seedling density occurred when the burn depth extended into the fermentation layer. (The forest floor is stratified with the litter layer at the top, humus layer at the bottom, and a fermentation layer sandwiched in between.) However, he observed that the seedling count decreased appreciably when burn depth extended into the humus layer, and approached zero when most or all of the humus layer was consumed.

"On sites with this kind of vertical distribution of stored seeds, there is a good chance that we could get rid of a large proportion of the seeds with a deep consumptive burn," he asserted.

The depth of burn depends critically on the moisture content of the forest floor or duff. To get a highly consumptive burn, duff moisture must be low, and that generally means burning in the late spring or early fall.

Should highly consumptive preharvest burns turn out to be an effective approach for reducing shrub problems, one potential drawback would be excessive smoke production.

"The smoke problem could limit the use of the technique," Weatherspoon admitted, "but the problem must be viewed relative to the benefits and costs—including environmental costs—of alternative vegetation management techniques."

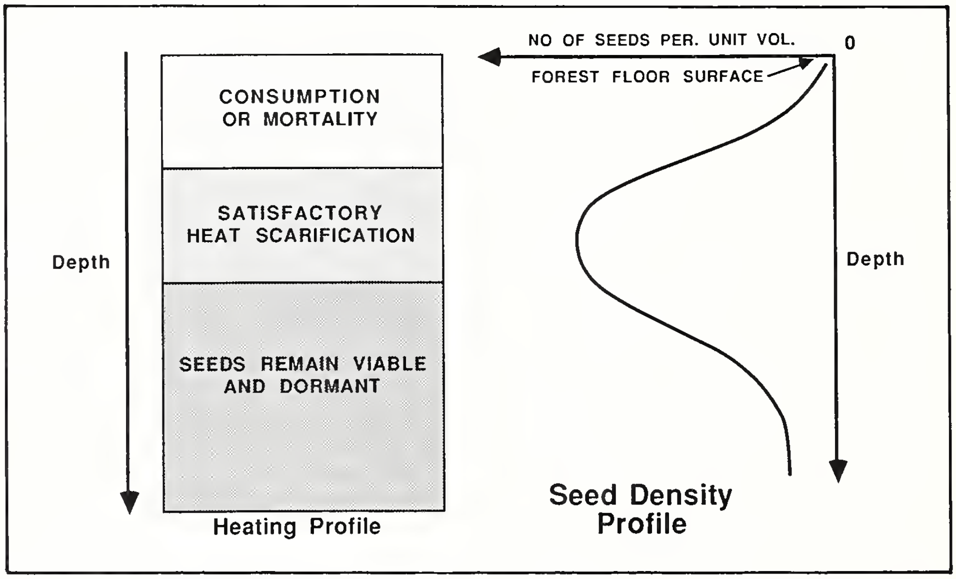
As for potential adverse impacts on soil quality, Weatherspoon doubts that a consumptive preharvest burn would, in most cases, be more damaging than mechanical site preparation techniques currently in use. Neither does his evidence suggest that unacceptable damage to residual trees would be a problem. He will be addressing both of these questions, however, in future work.

How applicable?

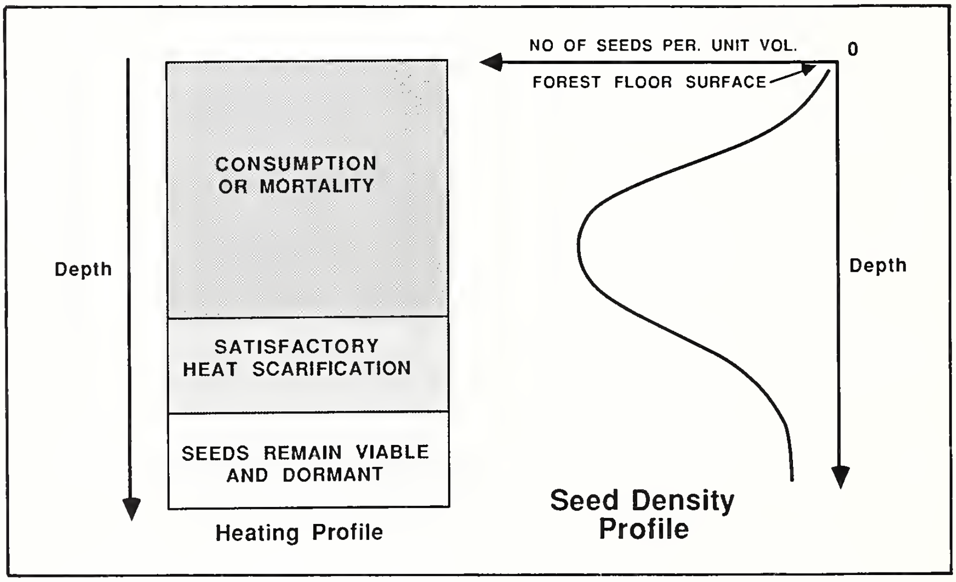
An unexpected finding in the present study was the very low number of seedlings found in thinned but unburned plots. The observation begs the question: 'Why burn at all if postharvest vegetation was so low after logging in the absence of fire?'

"That's a good question," grants Weatherspoon. "My answer must be that on some sites it might indeed be a good idea not to conduct either a preharvest or a postharvest burn. In our particular study area in a high elevation true fir forest, it would certainly seem to be the case. Our data indicate that no significant shrub problems would have resulted from mechanical site preparation."

However, Weatherspoon stressed that if site preparation is to be conducted on steep slopes, broadcast burning is usually the only practical alternative. Furthermore, in many areas vegetation growth is a significant problem after site preparation with mechanical methods as well as with broadcast burning. "On a lot of sites there's a broader range of site preparation techniques in which preharvest burning could give the forester an advantage," Weatherspoon noted. Such is the case in much of the mixed conifer forest type in which he will concentrate future experiments.



The number of shrub seeds killed outright and the number of seedlings produced per unit area depend on the interaction of the temperature profile associated with a fire and the seed profile in the forest floor and soil. In the lower scenario, more duff is consumed, more heat is produced, and more stored seeds are destroyed than in the upper one.



In the meantime, silviculturists whose interest has been piqued by these early findings will be following closely the results of Weatherspoon's research.

"If its potential is realizable," says Weatherspoon, "then preharvest burning certainly would be worth adding to our existing repertoire of vegetation management techniques."

A true multi-resource species

by Rick Fletcher
Rocky Mountain Station

While stands on the drier eastern slope of the continental divide are mostly concentrated in draws and other moist areas, stands on the west slope occupy large areas on all physiographic positions.

"Aspen—the very name calls to mind an image of beauty, serenity, and autumn splendor." So begins the latest in a series of publications by the Rocky Mountain Station on the state-of-the-art in silviculture of this species in the central and southern Rocky Mountains. The new booklet, *Silviculture of Aspen Forests in the Rocky Mountains and Southwest*, which is actually a companion to a slide/tape program, offers a concise summary of the ecology and suggested silvicultural practices in these regions.

Aspen is one of the most widely distributed tree species in the world, yet is the tree which best typifies the rugged beauty of Rocky Mountain forests. Several million acres of aspen in the central Rockies not only furnish important recreational and scenic areas, they also provide valuable wildlife habitat, and represent a largely un-utilized fiber resource. In fact, it is the only hardwood species being managed in the Rocky Mountain and Southwest regions.

A true multiresource species, aspen in some way affects all natural resource management disciplines in the West. From a silvicultural standpoint, aspen behaves quite differently than its associated conifer species. Selection of a silviculture system to manage the tree within the reality of conflicting resource uses can, at times, be quite complex. It is for this reason that scientists at the Rocky Mountain Station developed this booklet.

The 38-page publication covers stand conditions, clonal characteristics, damaging agents, silvicultural methods for regeneration, and factors that affect regeneration success.

Productivity and development of aspen in the Rockies depends largely upon available moisture which, in turn, is related to weather patterns, elevation, physiographic position, and soil characteristics. Annual precipitation ranges from 16 to 40 inches per year, most of which is received as snow.

An interesting feature of aspen forests is their age. The average age of most stands is around 100 years, with the majority being between 80 and 120 years of age. Younger stands are rare and are found only where there has been a recent disturbance to kill the overstory and trigger reproduction. The result is an overabundance of stands in the mature to overmature age classes. While 80 to 120 years seems relatively young by western conifer standards, aspen seldom persists to these ages in other parts of its range.

Aspen foes

An important limiting factor for aspen is its susceptibility to insects and diseases. The western tent caterpillar is one defoliating insect which can be quite serious. Scientists have found that *Bacillus thuringensis*, in a water suspension spray, can be very effective in controlling this insect.

Aspen is also host to several boring insects, which can lower the product value of the tree and promote cankers and other diseases. Roundheaded and flatheaded woodborers are two of the most notorious.

In the West, aspen reproduces almost exclusively by suckering, where a number of stems are produced asexually from a parent root system.

Cankers are by far the most common disease threat to aspen. They deform and kill trees, and cause serious losses in high-value stands. Several species of cankers commonly infect trunk wounds—*Hypoxylon* canker, *Cenangium* or sooty bark canker, *Cytospora* canker, *Ceratosystis* or black cankers, and *Cryptosphaeria* canker.

Regeneration

Station researchers point out that the most important thing to remember about aspen is that it does not regenerate the same way conifers do—it reproduces almost exclusively by suckering, where a number of stems are produced asexually from a parent root system.

Suckers are produced when overstory stems are removed or die. This causes a hormonal imbalance, which stimulates buds located just below the soil surface on lateral roots to sprout and grow. As a result, a genetic individual is not a single stem as in conifers, but a group of genetically identical stems, referred to as a clone. Thus, an entire mountainside of aspen may contain only a few genetic individuals.

Silvicultural treatment

Aspen is ideally suited to management by an even-aged silvicultural system using clearcutting or other regeneration methods which completely remove the existing overstory in one step and eliminate the chance of residual stem infection. The booklet covers silvicultural systems, including partial and clearcutting, and the use of prescribed fire, bulldozing, and herbicides.

Although most aspen stands will regenerate themselves if the overstory is removed or destroyed, scientists have found that some isolated stands that are poorly stocked and have many damaged stems, will not successfully reproduce. These stands are also likely to be under insect and disease attack, and be experiencing heavy understory browsing and/or root compaction or trampling damage by livestock or big game animals. The book covers options for these stands, such as fencing or locating salt and water to draw animals away, and removal of competing conifers.

Other factors that may affect regeneration are also mentioned. An important one is browsing—which can be a serious problem for the first few years until suckers grow beyond reach of animals. In addition, small animals such as voles can girdle suckers and kill young stands, and heavy snowfall can break stems and strip branches from suckers.

Today's resource specialists must manage aspen stands to meet a variety of objectives—scenic and recreational, timber, and wildlife habitat. These latest research findings are helping managers make better silvicultural decisions for aspen forests in the central and southern Rockies.

If you would like more details, write for a copy of technology transfer booklet No. 7. The Rocky Mountain Station has copies.

The 22-minute slide/tape program, produced by the Rocky Mountain Station, is available from Audio-Visual Services, Clark Building, Colorado State University, Fort Collins, Colorado 80523, at a cost of $106.80 including shipping. The program is also available on 1/2 inch video tape for $30.00 plus shipping, and on 3/4 inch video tape for $35.00 plus shipping. Copies of the slide/tape have been distributed to the Intermountain, Rocky Mountain, and Southwestern Regions of the USDA Forest Service.

If you desire more information about aspen management, a more comprehensive and technical summary of subjects covered in this booklet is presented in the following publication: DeByle, Norbert V., and Robert P. Winokur, editors. 1985. Aspen: Ecology and Management in the Western United States. USDA Forest Service General Technical Report RM-119, 283 p. Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colorado. Copies can be purchased as Stock No. 001-001-00617-3 from Superintendent of Documents, Washington, D.C. 20402 at a current price of $8.50.

Snow damage can affect regeneration as the weight of the snowpack breaks stems and strips branches from suckers.

New Publications

Streamflow trends at Fraser

A watershed ecosystem approach is often used to detect long-term trends in surface water chemistry attributable to land use, and to estimate the potential effects of human-caused atmospheric inputs.

The Rocky Mountain Station has just issued a paper on inorganic streamwater chemistry data gathered at the Fraser Experimental Forest in central Colorado. Data gathered in 1982 and 1984 are compared to collections made at the same sites in 1965 and 1970-71.

The paper provides a baseline against which future changes resulting from atmospheric inputs and watershed manipulation might be measured; examines historical trends attributable to environmental changes that have taken place since 1965; examines relationships between precipitation, streamwater discharge, and nutrient concentration; and compares precipitation and stream chemistry data at Fraser with other locations in Colorado.

Details are available in *Trends in Streamwater Chemistry and Input-output Balances, Fraser Experimental Forest, Colorado*, Research Paper RM-275.

United States
Department of
Agriculture

Forest Service

Rocky Mountain Forest and Range Experiment Station

Fort Collins,
Colorado 80526

Research Paper RM-275

Trends in Streamwater Chemistry and Input-Output Balances, Fraser Experimental Forest, Colorado

Robert Stottlemyer and Charles Troendle

Montana timber supply report released

Results of a Montana timber supply study show a reasonably optimistic future for maintaining recent harvest levels, except in the northwest part of the State. This result, and others, is explained in a new INT report, *Montana's Timber Supply: An Inquiry Into Possible Futures*, Resource Bulletin INT-40.

The report is a result of a 2-year multi-agency study, sponsored by the Montana Department of State Lands, Division of Forestry; the University of Montana School of Forestry; and the Forest Service's Northern Region and Intermountain Research Station.

The study showed a general Statewide increase in total timber inventory, despite decreases in inventory on forest industry lands. The study also revealed a trend toward harvest of smaller trees and toward increasing prices for timber.

Copies of the publication are available from the Intermountain Station.

Pinyon-juniper conference proceedings available

Early in 1986, scientists and managers from across the West gathered in Reno, Nevada, to discuss problems and opportunities related to the management of pinyon-juniper woodlands.

A new INT report makes available the information contained in over 100 papers presented at the conference. The report groups the papers into 12 categories; general session, synecology, paleobotany, fire in pinyon-juniper woodlands, economics, inventory and classification, silvics and silviculture, woodland conversion, nutrient cycling, plant-water relations, range management, woodland hydrology, and woodland wildlife.

Request *Proceedings—Pinyon-Juniper Conference*, General Technical Report INT-215.

ROS outlined

In the late 1970's, the USDA Forest Service, along with other land management agencies, recognized a need to better integrate recreation into multi-use planning. To meet the need, Forest Service specialists designed a recreation planning and management system, quite different from any predecessors, called the Recreation Opportunity Spectrum (ROS).

A new report is out that describes this system and suggests research that might be undertaken to test its utility and validity. Such research would be particularly timely because land management agencies in the U.S., Canada, Australia, and New Zealand have adopted and transformed it into agency-specific operating systems. Officials in Asia and Scandinavia are also considering it for their use.

Details on the evolution of the concept of ROS, in addition to recreation planning system needs of the USDA Forest Service and USDI Bureau of Land Management, are available in the reprint *The ROS Planning System: Evolution, Basic Concepts and Research Needed.* The Rocky Mountain Station has copies.

PNW publications illustrate the need for long-term studies

Four recent publications from the Pacific Northwest Station report the results of long-term studies and illustrate the importance of accumulating and comparing data over many years—or decades—in much of forestry research. A fifth lists the papers, theses, and abstracts that describe work done over 38 years at an Experimental Forest, and still another lists studies that have been done on Research Natural Areas in Oregon and Washington.

Research Publications of the H.J. Andrews Experimental Forest, Cascade Range, Oregon 1948-1968 (General Technical Report PNW-201), compiled by Arthur McKee, Gary M. Stonedahl, Jerry F. Franklin, and Frederick J. Swanson, lists almost 600 references alphabetically by senior author and cross-indexes them under 138 subjects that range from road development to detritus processing. The range of subjects indexed illustrates the breadth of information that has come from the Experimental Forest. One reason it has been heavily used for research is that records of such environmental conditions as precipitation, temperature, streamflow, and humidity go back at least 30 years. Extensive and intensive past work provides a context for new studies, and new studies add to the emerging overall understanding of how the ecosystem works, in addition to making their individual contributions. Established in 1948 as one of the Forest Service's premier research properties, the Andrews has been called "The most studied in the world."

The titles and subjects of the publication listed reflect changes in research emphasis over the years. Early studies were about the efficiency of logging and road systems and the success of forest regeneration. Then came studies about the effects of logging on watersheds. Gradually, ecosystem studies increased and now represent about half the work. Titles include such subjects as nutrient cycling, ecology of large woody debris, and mortality of trees.

Research Natural Areas in Oregon and Washington: Past and Current Research and Related Literature (General Technical Report PNW-197) by Sarah E. Greene, Tawny Blinn, and Jerry F. Franklin identifies more than 200 research projects that have been conducted since 1931 and lists more than 500 publications. Research projects are listed for each Area (arranged alphabetically), followed by information on the status of projects, sources of funding, and principal investigators and addresses. Published research is listed in the reference section. An appendix identifies all Research Natural Areas by name and managing agency.

Another three publications relate specifically to the long-term effects of the silvicultural treatments of spacing and thinning. A fourth deals with the effects of insect-caused defoliation on subsequent tree growth.

Growth and Yield of Western Larch in Response to Several Density Levels and Two Thinning Methods: 15-Year Results (Research Note PNW-455) by K.W. Seidel, reports on a levels-of-growing-stock study begun in 1970 in the Blue Mountains of northeastern Oregon. The even-aged stand was thinned from above and below at age 55. The 15-year response indicates that basal area and volume growth increased with stand density for both thinning methods, whereas diameter growth decreased. Thinning from below is recommended in previously unmanaged larch.

In *Fifteen-Year Results From a Grand Fir-Shasta Red Fir Spacing Study* (Research Note PNW-458), Seidel reports that a 43-year-old, even-aged stand in central Oregon responded to release and thinning with diameter and height growth two to three times the prerelease rate. Increased growth after release suggests that saving the advance reproduction of true fir can be desirable but that the potential for loss from heart rot should be considered.

Early Lessons From Commercial Thinning in a 30-Year-Old Sitka Spruce-Western Hemlock Forest (Research Note PNW-448) by Sarah E. Greene and William H. Emmingham reports on a planned long-term study of the response of a 30-year-old stand on the Oregon coast to three thinning treatments. The stand had been precommercially thinned at 15 years to average spacing of about 13 feet. Results so far indicate that strip thinning, the cheapest treatment, caused fewer scars. The study is one of the first to look at scar damage before and after thinning in young stands. It sets the stage for future measurements that will provide information about long-term effects.

In *Radial Growth of Grand Fir and Douglas-Fir 10 Years After Defoliation by the Douglas-Fir Tussock Moth in the Blue Mountains Outbreak* (Research Paper PNW-367), Entomologist Boyd Wickman points out that short-term tree-growth response to defoliation may not always relate strongly to long-term stand development. The effects of site, nutrient cycling, competition, and local environmental conditions all contribute to tree growth, and even one factor, such as precipitation, can have different effects, depending on timing and distribution. He cautions against using radial-growth data to justify pest management practices.

Measurements made on plots established during the 1972-73 outbreak of the Douglas-fir tussock moth to study various forms of tree damage indicate that for the period 1978-82, growth of grand fir was significantly greater than growth in the preoutbreak period of 1968-72. Growth recovery for Douglas-fir was similar but not as pronounced.

Copies of all the publications mentioned are available from the Pacific Northwest Station.

United States Department of Agriculture

Forest Service

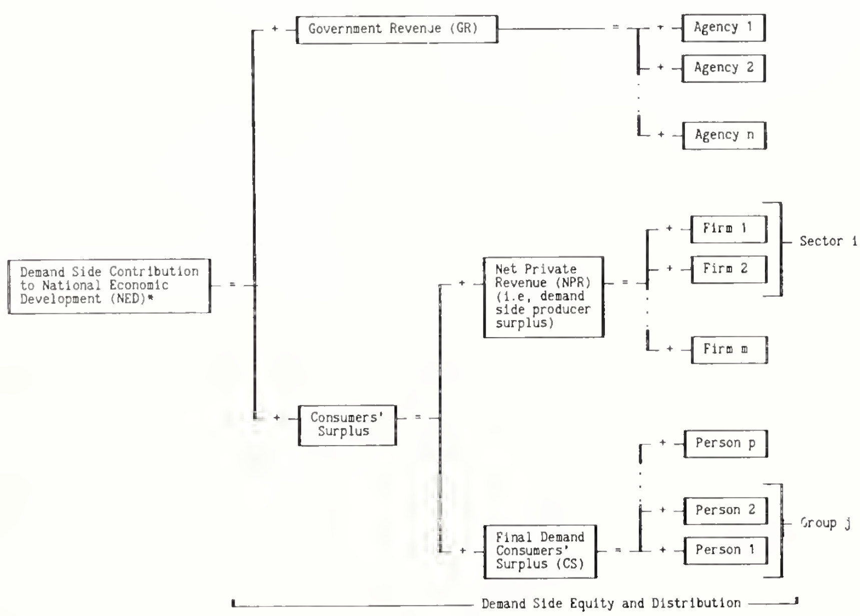
Rocky Mountain Forest and Range Experiment Station

Fort Collins, Colorado 80526

General Technical Report RM-138

An Improved Framework for Estimating RPA Values

George L. Peterson, Thomas C. Brown, and Donald H. Rosenthal



* For net contribution to NED, supply costs (including external costs) must be subtracted.

Estimating RPA values

The Forest and Rangeland Renewable Resources Planning Act (RPA) was designed to make natural resource planning more rational and accountable. As part of the planning process, alternative national plans are developed that reflect various resource management goals. Demand-side unit values are estimated for each resource output or category of outputs to compute the value of benefits generated by these alternative plans. These unit values are referred to as "RPA values".

A new report issued by the Rocky Mountain Station offers an improved framework for defining and estimating RPA values. The paper covers the philosophical basis for valuation, objectives to be served by the evaluation, alternative planning models and pricing policies, National Economic Development guidelines, and approaches to estimating RPA values.

For your copy of *An Improved Framework for Estimating RPA Values*, General Technical Report RM-138, write the Rocky Mountain Station.

To order any of the publications listed in this issue of *Forestry Research West*, use the order cards below. All cards require postage. Please remember to use your Zip Code on the return address.

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- ☐ *Research Natural Areas in Oregon and Washington: Past and Current Research and Related Literature*, General Technical Report PNW-197.
- ☐ *Growth and Yield of Western Larch in Response to Several Density Levels and Two Thinning Methods: 15-Year Results*, Research Note PNW-455.
- ☐ *Fifteen-Year Results from a Grand Fir-Shasta Red Fir Spacing Study*, Research Note PNW-458.
- ☐ *Early Lessons from Commercial Thinning in a 30-Year-Old Sitka Spruce-Western Hemlock Forest*, Research Note PNW-448.
- ☐ *Radial Growth of Grand Fir and Douglas-Fir 10 Years After Defoliation by the Douglas-Fir Tussock Moth in the Blue Mountains Outbreak*, Research Paper PNW-367.
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- ☐ *Montana's Timber Supply: An Inquiry Into Possible Futures*, Resource Bulletin INT-40.
- ☐ *Methods of Evaluating Riparian Habitats with Applications to Management*, General Technical Report INT-221.
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Fire ecologies of forest habitats available

Fire as an ecological factor for forest habitat types is described in two new INT reports.

In the first publication, available information for forests in central Idaho is summarized. Based primarily on fire's role in forest succession, habitats are grouped into 11 fire groups. For each fire group, information is presented on (1) the relationship of major tree species to fire, (2) fire effects on undergrowth, (3) fire effects on wildlife, (4) forest fuels, (5) the natural role of fire, (6) fire and forest succession, and (7) fire management considerations.

The second report describes similar information regarding fire and forest habitats in western Montana.

Request, *Fire Ecology of the Forest Habitat Types of Central Idaho*, General Technical Report INT-218, and *Fire Ecology of Western Montana Forest Habitat Types*, General Technical Report INT-223.

Evaluating riparian habitats

Many public resource managers in the West believe that conflict surrounding the management and use of stream-riparian areas is the most potentially explosive land management issue of the day.

Managers need to know how to evaluate streams and riparian areas, and then tailor their management regimens accordingly. A new INT report will aid them in this effort. INT Fisheries Biologist William Platts and others have compiled the latest methods for resource specialists to use in managing, evaluating, and monitoring riparian conditions adjacent to streams, lakes, ponds, and reservoirs. The report, when used with *Methods for Evaluating Stream, Riparian, and Biotic Conditions*, General Technical Report INT-138, provides users with a complete methods procedure for evaluating stream-riparian habitats.

To obtain a copy of the report request, *Methods for Evaluating Riparian Habitats With Applications to Management*, General Technical Report INT-221.

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